

## Response to the 2005 Western Atlantic Coral Bleaching Event

**Draft prepared by A. Bruckner, NOAA Fisheries, Office of Habitat Conservation**

### **Introduction**

There is a need to rapidly mobilize a team to respond to the coral bleaching event that is currently underway in Puerto Rico and the USVI. This is an unprecedented event characterized by an unusually long duration of higher normal temperatures, a large spatial extent of bleaching, and a high prevalence of complete bleaching affecting most colonies regardless of species or depth (Appendix I). Because the short-term impacts equals or exceed those of the 1998 bleaching event, it is important to collect information on the overall extent of bleaching over the next one to two months, and reexamine sites post bleaching (e.g., next spring/summer) to characterize the effect of the bleaching on coral reef community structure. These surveys will provide useful information on patterns of recovery or mortality of corals, possible changes to reef fish assemblages, and factors that increase or decrease the likelihood of bleaching and mortality. The information collected during this response would contribute to a 2006 GCRMN Reef Status report and will form an important component of the next US Status of the Reefs Report.

Many of NOAA's researchers and partners from Universities and Resource Management Agencies are monitoring coral reefs in Puerto Rico and the USVI. These partners as well as several NGOs (AGRRA, TNC, and REEF Check) feel there is a need for a coordinated response to address the current bleaching event and have expressed interest in participating in this response. Those that were contacted are listed in Appendix II.

The NOAA Coral Reef Conservation Program (CRCP) could participate in this bleaching response in several ways:

- NOAA CRCP could help support a regional and Caribbean-wide rapid assessment through the Reef Check network
- NOAA CRCP should also support and participate in a more rigorous evaluation. Ongoing monitoring efforts in PR and the USVI are using a variety of methods (Appendix III). As one possibility, the approach implemented by TNC for their broad 2005 assessment of bleaching in Florida could be applied to Puerto Rico and the USVI. This would provide a rigorous method to determine differences among the species affected, differences among size classes (e.g., are larger corals more likely to bleach than small colonies), degree of bleaching, occurrence of other causes of mortality (e.g., disease), impacts to affected corals (amount of partial and whole colony mortality) and associated species. This will provide a quantitative baseline for further monitoring. It would also allow a unique opportunity to compare the U.S. Caribbean and Florida (Appendix IV). We understand that this methodology will also be used on the Maya Reef in Belize & Mexico.

**Goals:**

- 1) Obtain information on the spatial extent of bleaching, patterns of recovery and/or extent of mortality, and effects of bleaching/mortality on fish assemblages
- 2) Identify factors that contribute to the variability in bleaching and resilience among locations, habitats, depths/zones and species throughout the U.S. Caribbean

**Objectives:**

- Compile existing monitoring data for Puerto Rico and The USVI, targeting areas for which there are pre-bleaching data as well as areas for which the bleaching information will form a baseline.
- Identify gaps in existing monitoring coverage and select priority sites that should be included in a synoptic assessment. Come to consensus on standard or comparable approaches to apply throughout the region.
- Collect baseline information on the extent of bleaching from key sites throughout Puerto Rico and the USVI in collaboration with all government, academic and NGO partners. This could include sites within established monitoring programs as well as other key locations. One component may incorporate rapid surveys over a broad spatial scale (e.g., using Reef Check volunteers), with more detailed assessments (e.g., measurements of colony size, mortality and condition such as that used by TNC) at priority sites throughout the region.
- Conduct post bleaching evaluation some 4-6 months later in the same locations to determine the extent of partial and total colony mortality from bleaching and any effects on the associated community including reef fish assemblages.
- Use information to identify sites and species most susceptible to bleaching and those that did not bleach or exhibit a lower degree of bleaching. Compare patterns of bleaching and recovery with coral community structure and environmental parameters to identify factors that contribute to resilience.

**Background:** A major coral bleaching event is underway in the Caribbean. Bleaching was first observed in Florida during August, 2005. As the warm water has moved southward, bleaching spread to the USVI and Puerto Rico and throughout much of the eastern Caribbean. Reports of bleaching have come in from U.S. locations, including the Florida Keys, southeastern Florida, Texas' Flower Garden Banks, Puerto Rico, and the USVI. Bleaching has also been reported from other Caribbean nations including Bahamas, Barbados, Belize, British Virgin Islands, Colombia, Costa Rica, Cuba, Jamaica, Mexico, Panama, and Trinidad and Tobago. To date, the most severe bleaching appears to have occurred in Puerto Rico and the USVI.

Initial signs of thermal stress were noted in late May, with an escalation of thermal stress around Puerto Rico and the USVI since late September. Summer and fall water temperatures have been as much as 2 ° C above historic monthly maximums in some areas. As of October 11, thermal stress had reached Degree Heating Week (DHWs) values of 7.6 for southwestern Puerto Rico and 8.2 for USVI, which exceeds previous record DHWs observed in 1999 (PR) and 1998 (USVI) (Coral watch posting, Oct. 11,

2005). By October 25 DHW values exceeded 12 through much of this area and temperatures were still 0.9°C over maximum monthly mean for the USVI, and 0.4 °C for the Puerto Rico site (Coral Watch posting, Oct. 25, 2005). The effects of elevated water temperatures are likely to have been exacerbated in some locations by doldrums-like conditions and increased penetration of harmful UV radiation. However, recent hurricanes may also have helped cool waters in other locations.

Reports of bleaching began in mid August 2005, and by September extensive bleaching was occurring in Puerto Rico and USVI. Bleaching is being observed in scleractinian corals, hydrozoan corals, zoanthids, and gorgonians with up to 42 species affected (Weil, pers. Comm. \*) including corals like *Mussa angulosa* that don't usually bleach. Between 50-90% of corals are fully bleached at some sites, including large monospecific stands of *Montastraea annularis* (e.g., St John) and *Acropora cervicornis* (e.g., eastern Puerto Rico). Bleaching is occurring down to 45 m at Bajo de Sico (in Puerto), mostly *Porites astreoides*, but also of many other corals and hydrocorals (Stylaster is all white), including coral spp that usually do not bleach, such as *M. cavernosa*; colonies of *M. annularis* and *Agaricia* spp. are also bleached in deeper areas off the USVI. Partial and whole colony mortality has been observed in colonies of elkorn and staghorn coral (St Croix), as well as the hydrozoan coral *Millepora* and the zoanthid *Palythoa* (eastern Puerto Rico).

A recent report from eastern Puerto Rico indicates that some of the corals appear to be recovering. Further verification is needed. There are also indications that bleached colonies in some areas are being affected by known (e.g., white plague II) and possibly newly emerging diseases (unusual diseases in Acropora, swollen polyps etc.)

### **Possible Responses:**

#### **1. Compilation of existing *in situ* survey data and information:**

Monitoring is underway at permanent sites in southwest Puerto Rico (8 locations), Eastern Puerto Rico and Culebra (10 locations), St. Croix (14 locations), St. John (3 locations) and St. Thomas (16 locations) for which pre-bleaching data exist. Additional data may be available from other sites (e.g., NOS monitoring in St. Croix and La Parguera; NMFS monitoring western PR, Mona and Desecheo Islands).

**2. Detection of spatial extent using satellite imagery:** Satellite imagery can provide one way to track the location and distribution of bleaching events. There has been some limited success using high-resolution satellite imagery to identify bleached areas (notably on Heron Island in the Great Barrier Reef). The spectral characteristics of the satellite, the ability to collect timely imagery, and other factors (e.g., the spectral characteristics of non-bleached and algae-overgrown coral), limit being able to use these technologies for monitoring large scale bleaching events.

NOS is in the process of purchasing IKONOS high resolution satellite imagery of all of St John, the eastern portion of St Croix (including Buck Island and the East End Marine Park), and a portion of southwestern Puerto Rico (La Parguera). This imagery is in the

queue for collection now and we anticipate receiving attempts any time. We will then evaluate the imagery with regard to its usefulness for mapping and tracking bleaching impacts. *We also need to follow-up with NASA to see what additional resources may be available.*

### **3. Conduct a broad scale rapid assessment**

- A rapid Caribbean wide assessment of the extent of bleaching could be undertaken at a relatively low cost using Reef Check volunteers. Surveys could provide general information on the percent of corals bleached for a large number of sites.

### **4. Conduct detailed quantitative surveys**

#### Methodology

- Ongoing efforts use different methods to assess prevalence and extent of bleaching (e.g., video transects, digital images, quadrats, belt transects, radial arcs, assessment of colony condition and size) and patterns of recovery/mortality (e.g., tagged colonies, reexamination of permanent transects).
- TNC has developed an approach which was tested at 116 sites in Florida. It provides information on the density and size structure of corals, the condition of corals (amount of recent and old partial mortality) and degree of bleaching
  - o Use of this method would allow regional comparison.
  - o This method is closest to the approach used in the USVI by Rick Nemith's team (UVI) and Caroline Rogers Acropora monitoring program and by Bruckner and Hill in Puerto Rico.

#### Possible sites

Sites should include representative habitats and zones, including inshore, mid shelf and outer reefs, different depths

- Priority areas with no existing effort such as Vieques, Mona Island and Desecheo Island
- Deep reefs and shelf edge reefs
- Areas with unique assemblages of corals (e.g., Acropora stands off Rincon and Bajo Gullardo)
- Areas with existing permanent stations but no planned monitoring

### **5. Conduct a CDHC response in coordination with field surveys**

- Samples could be taken from affected and unaffected corals for microbiology and molecular biology and histology to characterize microbial communities, virulence factors, resistance and condition of tissue.

DRAFT 11/4/05

**POSSIBLE TIMING:**

November 16: Initial NOAA meeting (NESDIS, NOS and NMFS, including SEFSC) to discuss options

November 21 or 22: Conference call with partners to begin discussing priority sites and methodologies, identify team members, identify and discuss logistical issues.

November 21-30: Finalize plans

December 3: Potential meeting in Miami (SEFSC?) following Deep-Sea Coral Symposium.

Dec 5-23: Mobilize teams for field surveys

April/May 2006: Resurvey sites examined in November/December

## Appendix I: Synopsis of bleaching reports

Bleaching has been reported from researchers working in southwest Puerto Rico (Weil), Eastern Puerto Rico (Hernandez), St Croix (Rogers, Muller, Miller, Bryan, Keys), St. John (Miller, Nemeth) and St. Thomas (Nemeth).

### Species affected in Puerto Rico and USVI: (This is not a complete list)

- **Scleractinian Corals:** *Montastraea annularis*, *M. faveolata*, *M. franksi*, *M. cavernosa*, *Diploria strigosa*, *Diploria labyrinthiformis*, *Siderastrea siderea*, *Porites astreoides*, *P. porites*, *P. Furcata*, *P. Divericata*, *Agaricia (Undaria) agaricites*, *A. Lamarcki*, *Acropora palmata*, *Acropora cervicornis*, *Colpophyllia natans*, *Dendrogyra cylindrus*, *Mussa angulosa*, *Leptoseris cucullata*
- **Hydrozoan corals:** *Millepora alcicornis*, *M. complanata*, *Stylaster rosaceus*
- **Zoanthids:** *Palythoa caribaeorum*
- **Octocorals:** *Erythropodium caribaeorum*, Plexaurid gorgonians

**In St John**, bleaching was first noted on *Millepora*, *Agaricia*, and the zoanthid *Palythoa* in August. By mid September *Montastraea annularis*, *M. faveolata*, *M. franksi*, *Porites astreoides*, *Porites porites*, *Diploria labyrinthiformis*, *Colpophyllia natans*, and *D. strigosa* were severely bleached with less severe bleaching in *Acropora palmata*, *Acropora cervicornis*, *Dendrogyra cylindrus* and *M. cavernosa* (J. Miller and C. Roger, 9/30/05). At one site (Tektike Reef) 90% of the corals were bleached (J. Miller, pers comm.). An in situ temperature meter at 16 m in St John measured over 30 C since Sep 5, reaching a maximum of 30.8 C on Sept 26 (Miller and Rogers, 9/30/05).

**In St Croix**, as of October 17<sup>th</sup>, an estimated 70% of the hard corals around **Buck Island** were either partially or fully bleached. Almost all of the *Montastraea* colonies were completely bleached except for *M. cavernosa*, which were affected by partial bleaching. A majority of the *Acropora palmata* colonies were either bleached or partially bleached. *Diploria*, *Porites*, *Siderastrea*, *Millepora*, and *Palythoa* spp. were also affected. Most of the corals still appeared to be alive but there were a couple with signs of new algae growth. The hard corals on the reefs off **Cane Bay** were also experiencing significant bleaching. At less than 10m roughly 50% of the hard corals were bleached while at least 75% of the corals were bleached at depths greater than 10 m, including the deeper plated *Agaricia* colonies (Bryan, Oct, 20, 2005).

Off the **North shore of St. Croix** nearly 90% of the colonies were bleached, with exception of corals located in shallow water (<1 m) adjacent to shore (Melissa Keyes October 1, 2005)

Bleaching in *Acropora* is being monitored at **Salt Pond**. Of approximately 183 colonies of *A. palmata* within their study site, 32 showed signs of bleaching (ranging from bleaching tips to the entire colony), of which 6 now have completely died, 17 show signs of partial mortality, and 6 also have disease coupled with the bleaching. Mortality from bleaching took 21 days (first observed) or less. Of approximately 33 colonies of *A.*

*cervicornis*, all 33 colonies bleached; 9 have since died completely and 7 have suffered partial mortality from bleaching (Erinn Muller pers. Comm. Oct 28, 2005).

**Off eastern Puerto Rico** over 20 species had bleached by September 15, 2005.

Bleaching has impacted more than 90% of *Montastraea annularis* complex species and agaricids at each site. Nearly 100% of the shallow populations of *Millepora complanata* and *M. alcicornis* bleached and these died shortly later. *Diploria* spp., *Siderastrea siderea*, *Porites* spp., and other species were documented with total or nearly total bleaching as of September 9, 2005, while many plexaurid octocoral colonies, encrusting gorgonians (*Erythropodium caribbaeorum*) and zoanthids (*Palythoa caribbaeorum*) were also significantly bleached. Complete bleaching of *A. cervicornis* thickets has been observed in some areas. Some of the bleached *Palythoa* colonies were also beginning to die. A bleached colony *Mussa angulosa*, a species that has not been observed to bleach in this area during previous events, was also identified. Shallower reef zones appear to have been more affected than deeper reefs (Hernandez, Sep 9 and 15, 2005).

Shallow reef areas (above 12 m) off **La Parguera, southwest coast of PR** are exhibiting bleaching similar to what E. Hernandez reported for the eastern PR. Most large colonies of *Montastraea faveolata*, *M. annularis*, *Colpophyllia natans*, *Diploria strigosa* and *D. labyrinthiformis*, *Dendrogyra cylindrus*, *Undaria agaricites*, *Leptoseris cucullata*, *Agaricia lamarcki*, *Porites porites*, *P. furcata*, *P. divaricata*, *Siderastrea siderea* are the most affected within the hard corals. *Millepora* spp. *Erythropodium caribbaeorum*, *Palythoa caribbaeorum*, and many plexaurid octocorals, are also bleached. Deep reefs at the shelf edge and deep areas of coastal reefs are not showing bleaching signs yet. However, at the shelf edge (20 m) we have started to see a significant number of colonies (*M. faveolata*, *D. labyrinthiformis*, *D. strigosa*, and *C. natans*) with signs of white plague type II.

## **Appendix II: Possible Collaborators**

### **USVI**

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### **Reef Check**

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### **AGRRA**

Bob Ginsburg

### **NOAA**

#### **- Biological monitoring**

Mark Monaco/John Christensen and  
team, NOS

Ron Hill,  
NMFS Galveston

Andy Bruckner,  
NMFS Silver Spring

#### **- Coral Watch**

Mark Eiken,  
Al Strong,  
NESDIS

#### **- CDHC**

Cheryl Woodley –  
NOS  
Role: RAPID RESPONSE PROGRAM  
Coordination of sampling for laboratory  
analysis



### Appendix III: Methodologies used

***Rick Nemeth, Tyler Smith and others (UVI): (St. Croix, St. Thomas):***

Coral Reef Monitoring Project for St. Thomas, St. Croix and areas of St. John outside the national park

**Location:** 16 permanent sites St. Thomas and 12 in St Croix as well as 7 Acropora sites. These sites include in array of reefs on an inshore to offshore gradients with n = 4 sites per strata on nearshore (5-10 m), mid-shelf cay (5-10 m), mid-shelf ridge (10-30 m) and shelf-edge (30-50 m) reefs.

**Monitoring approach:** Random (the bulk of the sites) and fixed transects,. Same sites visited repeatedly.. Six 10 m transects per each site. Use a modified AGRAA transect intercept method, with a >10 cm cut-off for recording the % bleaching and disease and sizes of colonies. Assess the bleaching state of corals using one of the following categories: ok (unbleached), slightly pale, pale, very pale, partially bleached or patchily bleached (w/ %) and 100% bleached. Also video transects

***Jeff Miller (VI National Park)***

**Location:** Annual video monitoring in St John: Yawzi, Mennebeck and Tektite reefs; St Croix: South Fore Reef.

**Monitoring approach:** Random 10 m transects. Film with a video camera pointed at the bottom along the 10 meter transect. In the office capture adjacent images and superimpose random points on the images. Identify and quantify what benthic component is under the random points (and if coral, note disease or note that it is bleached). Erinn Muller also conducts 10x2m belt transect around each of the 20 random transects per site looking specifically for any diseases.

***Caroline Rogers and Erin Muller (St Croix):***

**Location: St. Croix**

**Monitoring approach:** Monitoring of individual *Acropora palamata* and *A. cervicornis* colonies. Each colony is measured (length, width height) amount of mortality is estimated, condition is recorded (e.g., bleached/disease/predation). Colonies are tagged and photographed at regular intervals..

***Edwin Hernandez Culebra and Fajardo, Puerto Rico***

**Location:** Permanent sites in Culebra: at Peninsula Flamenco, Play Carlos Rosaria, Impact Beach, Cayo Luis Pena, Culebrita and Los Corchos, and Fajardo: Palominitos and Palominitos, La Cordillera.

**Monitoring approach:** three depth zones, with 4 replicate/depth, 10-m long each transect. Sampling is conducted using high resolution digital images (7.2 MB). Also, we are sampling all corals within 1 m of each side of the transect line. So these account as tagged corals. We know the position and ID of each individual in a planar view.

***Ernesto Weil, University of Puerto Rico, Parguera, Puerto Rico)***

**Location:** Permanent sites in La Parguera (Turrumote, Romero, Enrique, Pelotas, Pinnacles, San Cristobal, Media Luna, Weimberg, Buoy, el Hoyo), Guanica (Middle reef) as well as one reef in Mona, Desecheo and Culebra.

**Monitoring approach** 5 band transects in each of three depth intervals (0-5 - 5-12 and > 15 m) in each reef site. Each band is 10 x 2 (20 sqm) and are hapazardly placed along the substrate. These are all permanent transects that could be monitored in the near future. All colonies within the band are counted and checked for diseases, bleaching or other conditions. Sponges, octocorals, zoanthids, and crustose algae are also inspected for signs of disease. In some reef localities we are tagging and mapping colonies along these transects to follow up.

***Reni Garcia: UPR (DNER and CFMC monitoring program)***

**Location:** Deep reefs off Mayaguez and Desecheo

**Monitoring approach :** We have sets of 6 permanent transects at 30 and 40 meters, plus eight 10 meter long random transects at 50 m in Isla Desecheo for the CFMC. I also have permanent transects at 15, 20 and 25 m for the DNER at at Isla Desecheo, which were last monitored in June-August, just before the bleaching event.

***Mark Monaco/Christensen/Kendall etc. NOS***

**Location:** benthic surveys at 97 hardbottom sites around Buck Island, St. Croix  
The surveys are done at randomly selected sites.

**Monitoring approach:** At each site, a 25 m transect tape is run out along a random heading. Benthic cover, including incidence of bleaching, is quantified within a 1m<sup>2</sup> quadrat at 5 randomly chosen sites along the 25 m transect. Photos of prominent features were taken.

***Bruckner/Hill NMFS Galveston lab/ HC headquarters***

**Location:** benthic and fishe surveys are conducted at seven locations around Mona Island, three locations at Desecheo, multiple sites off Parguera (nearshore, mid shelf and shelf edge locations), as well as sites off the west coast (e.g., Rincon and Bajo Gullardo). Galveston lab also has fish monitoring sites around St. John (Newfound/Haulover on the northeast and sites near Fish Bay on the southwest).

**Monitoring approach.** Benthic survey techniques include random 10m X 1 m belt transects and permanent radial arcs, each 10 m in diameter. All corals are recorded to species, sizes are measured (LXWX H) and a visual estimate of the amount of recent and old mortality is recorded. Causes of mortality are identified (e.g., type of disease, signs of predation, overgrowth/competition) and bleaching is characterized as complete bleaching (white), pale (some color remains), blotchy (bleached in “spots”), or partial bleaching (location and extent of bleaching, e.g., pale sides, bleached base...). We have not yet done any surveys within our study sites during this event. Fish surveys are a modification of the AGRRA belt transects (30 m X 2m)

**Melissa Keys (Cane Bay St. Croix, USVI**

Photo-monitoring using a digital camera. Following individual colonies over time including pre-bleaching status.

APPENDIX IV:

**FRRP Coral Bleaching In-water Rapid Assessment Protocol**  
**DRAFT 4:**

**Site Selection**

All sites will be predetermined by University of Miami/RSMAS and GPS coordinates will be assigned to each dive team in advance. The sampling design will largely be based on the two-stage stratified approach they have been utilizing for the past several years in the Florida Keys and Dry Tortugas (200m x 200m cells= a site). The FRRP spatial framework which incorporates subregions, reef types, and bathymetry will be used to identify distinct stratification units for all areas containing Holocene reef (Tortugas to Martin County) This framework will be revisited each year and iteratively improved to more accurately describe how reef community types are organized. Each survey site will have a primary, secondary, and tertiary set of GPS coordinates (first attempt to locate coral habitat at the primary coordinates- if it is not suitable, continue to the secondary or tertiary locations). Once at the proper site, it is critical that the exact location of the actual survey is recorded using a GPS. Drop a float at the site based on the numbers and then try and anchor or attach to a mooring ball as close as possible. In cases where the survey takes place immediately below an anchored boat, simply record the position of the boat once its position has stabilized.

**The Survey**

1. At each site, record the following information on your UW datasheet before each dive. (We strongly suggest that each team member fills in every category.)

- Name of recorder
- Date as day with two digits/abbreviation of month/year with two digits;
- Latitude; As determined by dGPS.
- Longitude; As determined by dGPS.
- FRRP site code ID number
- Reef Type (e.g. patch, bank, etc) (note- if the reef type surveyed appears different than predicted, please describe the actual Reef Type following the survey)
- Reef Zone/Habitat (e.g. reef crest, reef front, spur and groove, etc.) (note- if the reef zone/habitat surveyed appears different than predicted, please describe the actual reef zone/habitat following the survey)

2. In Time Start, record the time at which you start the first transect.

**Haphazardly** lay the 10-m transect line just above the reef surface. Make sure the line is taut.

*Note: Be sure to avoid and don't cross the other transect that is being set by a second surveyor. Lines should be at least 5m apart so data from the each transect are not autocorrelated, which can happen if you are too close and features of one transect impact the other (big corals for example). Stay away from the edges of the reef. Also try to avoid areas with abrupt changes in slope, deep grooves, large patches of sand or*

*unconsolidated coral rubble. Swim without looking down at the bottom as you unreel the line.*

The benthos survey can be made in three “passes” of the transect line as follows:

**First Pass**

Parameter	Method
None	Lay out and straighten line

**Second Pass**

Parameter	Method
Hard Coral Density	ID species all corals >4cm within the 10x 1m belt transect
Hard Coral Size	Max. length, width, and height of all corals >4cm within the 10x 1m belt transect
Coral Partial Mortality	% “recently dead” and “old dead” per colony within the 10x1 m belt transect
Tissue isolates	Record the number of isolated tissue fragments on colony.
Coral Bleaching	Score bleaching by code (0-3) per colony within the 10x1 m belt transect
Coral Disease	Identify coral disease occurrence per colony within 10x1 m belt transect

**Third Pass**

Parameter	Method
Juvenile live coral cover	All juvenile stony corals (<4cm diameter) counted within 10 x 1 belt.

**First pass:**

3. Swim a belt transect along the 10-m line. Tie the first end of the transect line off to a dead piece of coral, fire coral, gorgonian, or other feature that is not living coral. Once at the end of the transect (past the 10m mark), pull tightly and securing the line. Note the depth at the start and the end of the transect line (0m and 10m).

**Second pass:**

4. As you swim from one end of the transect line to the other, assess the cover, size and condition of each stony coral that is 4 cm in length or greater and for which any live or dead part of its skeleton is within 1 m of the transect line. Lay down the 1 m measuring pole perpendicular to the transect for scale. Try to work the same side of a transect line.
  - a. Identify scleractinians to species.
  - b. Measure the x, y, z dimensions of the colony with the 0.5 m measuring bar (or tape): *i.e.* the maximum length (x) and the maximum width (y) of the outward-facing colony

surface (both perpendicular to the axis of growth) as seen from above in planar view, and the maximum height (z) (parallel to the axis of growth) as seen from the side of the colony. Record these measurements to the nearest cm.

*Note: Colony boundaries can be difficult to recognize when parts of the coral have died and are overgrown by other organisms—particularly other colonies of the same species. Look for connected live tissues, connected skeletal deposits above a common base, and at the size and color of separated polyps.*

*Colonies derived from new recruits:*

- 1) *Live tissue, generally concentric with clear edge boundaries. Often have a raised “lip” at edges approximately 1-2 mm above underlying substrate/old dead coral.*
- 2) *Upward growth, branching evident.*
- 3) *Underlying substrate is very old dead.*

*Colonies derived from resheeting:*

- 1) *Live, often with preferred growth in one direction, edges on at least one side often “merge” with underlying substrate/dead coral.*
- 2) *Live tissue rarely displays upwards growth (branching) except at tips.*

c. Estimate the partial mortality (old and recent) of the whole colony surface. Try to round your percentage to the nearest 5% unless it is very small or very large, in which case try to round to the nearest whole number (e.g., 1%, 97%).

**"Old dead"** is defined as any non-living parts of the coral in which the corallite structures are either gone or covered over by organisms that are not easily removed (certain algae and invertebrates). If it is entirely “old dead”, indicate this on your data sheet as 100% “old death”, as long as you can identify it to either to the species (e.g., *Acropora palmata* by gross morphology; *Montastraea cavernosa* by polyp size and shape) or to the genus (e.g., *Diploria* by size of meandering ridges and valleys).

*Note: In some cases, a coral may be partially or completely overgrown by one of the species of brown, zooxanthellate clionid sponges. If you look closely you will observe the in/ex- current holes of the sponge and sponge tissue instead of live coral polyps. If you can see the coral skeleton beneath the sponge, and are able to identify it to genus or even species, include the affected area in your estimate of “old death” and note “Cliona overgrowth” in the corresponding Comments box.*

**"Recently dead"** is defined as any non-living parts of the coral in which the corallite structures are either white and still intact or slightly eroded but identifiable to species. Recently dead skeletons may be covered by sediment or a thin layer of turf algae.

*Note: How to assess corals that are detached from the substratum:*

- i. *If it has recently fallen, the length, height and % mortality should be measured as if it were still upright; write “fallen” in comments box.*
- ii. *A detached but wedged coral should be marked as “wedged” in the comments section (as it is likely to remain in this position for an extended period). If it has been fallen for long enough to have reoriented to grow upward in its new position, the “new” maximum length and maximum width should be measured, and the new outward-facing surface used for calculating % mortality.*

e. Scan over the surviving portions of the ENTIRE coral colony for any DISEASES and/or BLEACHED tissues present.

f. Characterize any DISEASES by the following color categories:

BB = Black band  
WB = White band (*Acropora* only)  
WS = White patches/white pox/patchy necrosis (*Acropora* only)  
WP = White plague  
YB = Yellow-band/yellow-blotch  
RB = Red band  
UK = Unknown

For more information about coral diseases see the disease cards (Bruckner & Bruckner 1998) or one of the following web sites:

<http://www.unep-wcmc.org/marine/coraldis/cd/index.htm>  
[http://www.coral.noaa.gov/coral\\_disease/](http://www.coral.noaa.gov/coral_disease/)

Characterize any BLEACHED tissues as approximate severity of discoloration:

0 = No bleaching  
1 = Pale (discoloration of coral tissue)  
2 = Partly Bleached (patches of fully bleached or white tissue)  
3 = Bleached (tissue is totally white, no zooxanthallae visible)

*Many severely bleached corals are translucent, but you can still see the polyp tissues above the skeleton. Bleached tissues should not be included with the “recently dead” estimates.*

*Note: It is important to be able to differentiate between tissues that are alive but look white because they are bleached and white, recently dead skeletons.*

### **Third pass:**

Go back and swim a belt transect along the 10-m line counting all live juvenile stony corals (< 4 cm in diameter).

*Note: you do not need to record juvenile coral species or condition as this information will only be used to determine total live stony coral cover of the transect.*

7. After you complete a transect, collect the line
8. Repeat the above steps for a total of 2 transects per site (or 1 transect each for two observers). This should take no more than 30 minutes per site.
9. After surveying, either transcribe slates to paper and then enter data to spreadsheet, or enter data into spreadsheet and print out a copy. Enter your data into a copy of the provided FRRP spreadsheet in Microsoft Excel. (Be sure to use a separate copy of the spreadsheet for every SITE.) Please check your data to verify its accuracy, then submit an electronic copy. Back up your own data regularly and store it in a safe place.